

**This syllabus reflects the nature of the course when it was most recently taught.
All syllabi are subject to change by the instructor.**

**90-828 / 88-412 The Economics of Global Warming
Spring 2010**

Professor:

Lee Branstetter

Required Materials

The CAMEO E-Reader. Unless otherwise noted, required readings for this course can be accessed from the CMU Library CAMEO website (cameo.library.cmu.edu). Go to CAMEO, select “course reserves,” and then enter either my name or either of the course numbers for this course. That will direct you to electronic copies of the required readings that can be accessed online or downloaded. There are multiple pages of links to the readings; to access the later pages select “forward” from the menu at the top. To access the earlier pages, select “back.” Please be aware that the articles are in alphabetical order, not the order in which they appear in the syllabus. This is a limitation of the software. While it may be inconvenient to look up readings in this fashion, it is a much cheaper way of giving students access to the material than a traditional course reader, which has cost well over \$100 in recent years.

Course WebPage: This course will use the Blackboard system. As of the first day of class, all registered students should have complete access to the course web page. Important class information, including copies of the lecture notes, will be distributed regularly via this web page. Please check it often.

Course Objectives

The scientific community has concluded that human industrial activities are causing global temperatures to increase. Coping with the environmental, economic, and political consequences of this change is considered by many to be the preeminent public policy challenge of the 21st century. If ever there were a topic that required an interdisciplinary approach, this is it. Drawing upon the strong tradition of rigorous, interdisciplinary research and education at Carnegie Mellon and a broad range of expertise resident in its schools and departments, this course is designed to introduce masters students and advanced undergraduates to the many different dimensions of the global warming problem. In this course, we will investigate the science of climate change, the prospective economic impact of global warming, the uncertainty involved in long-run climate forecasting, and the technological alternatives available to us as we seek to mitigate the impact of human industrial activity on global warming. The heart of this course will be an in-depth analysis of the policy options available to the United States and the global community. We will investigate the economic costs of these options and the way political realities are likely to shape and constrain policy at the national and international levels. This course will also introduce students to the range of courses and research activities underway at CMU for those who want to study this issue in greater depth.

Pre-requisites

Introductory economics required at the level of 90-710 or equivalent.

Who should take this course

Anyone who is interested in understanding the realities of ongoing global climate change, its economic and social impact, and the policy alternatives available to the human race at the beginning of the 21st century. The course will be open to masters students in Tepper and the Heinz School as well as upper level undergraduates from H&SS, CIT, and SCS.

Course Structure

The course will be divided into four sections.

Part 1 – What on Earth is Going On?: The Science of Global Warming

The first section of the course will present the essential scientific facts undergirding the strong consensus within the scientific community that human industrial activity is changing the Earth's climate. Students will be introduced to the basic chemistry and physics behind global warming. This part of the course will feature a guest lecture from one of CMU's climate change experts, Professor Peter Adams. Students will contend with the difficulties involved in climate change forecasting and the substantial uncertainty that surrounds our forecasts. Students will also be introduced to the concepts and analytical tools used to assess the economic impact of climate change. We will review how economists attempt to compare the costs and benefits of climate change policies -- a subject we will return to in greater depth in Part 3.

Part 2 – Technology Alternatives

This portion of the course will examine technological alternatives to current power generation, transportation, and production technologies that contribute to global warming. We will examine various options including clean coal technologies, nuclear power, biofuels, and carbon sequestration. We will also examine the possibility of using technology to interfere with the Earth's climate in ways that could slow or reverse global warming. In reviewing these alternatives, we will draw upon the research and expertise of a number of CMU scholars, including Ed Rubin. We will also hear from John Goosen of Westinghouse, who will discuss the renaissance of interest in the nuclear power industry in the United States and Josh Linn of RFF and MIT, who will discuss solar power and wind power options. Former U.S. Secretary of the Treasury and former CEO of ALCOA, Paul O'Neill, will provide his own perspective on these issues as someone who worked in government and industry at the highest levels. At the end of this section, students will be required to write a "technology policy memo" that evaluates these technology alternatives.

Part 3 – What Do We Do Now?

This portion of the course reviews the public policy debate concerning what steps should be taken now to deal with the global warming, even when its ultimate consequences remain unknown. We will closely examine the economic arguments for and against carbon taxes and emissions cap-and-trade regulatory systems. Students will be introduced to the economic and mathematical models on which the arguments for these policy options are based. We will discuss how such regulatory regimes might operate in practice, both nationally and

internationally. We will discuss how the economic policies described in this section of the course could be harnessed to support the further development of the technological alternatives outlined in the previous section.

Part 4 – The Politics of Global Warming

Political considerations and clashing interests of different groups within society will inevitably shape and constrain the evolution of public policies to mitigate climate change, both in the United States and overseas. We will examine the imperfections and limitations of the Kyoto agreement and lessons that can be derived from this. We will examine the mistakes made in the implementation of a cap-and-trade emissions regulation regime in Western Europe and of a carbon tax in other countries, and discuss what lessons can be derived from this. We will also hear from Washington-based participants in the U.S. public policy debate, and discuss the prospects for meaningful shifts in American policy under the next Presidential administration.

Requirements and Grading:

Class participation – 10%: Class discussions are an integral part of the course, and class participation will account for **10%** of the total grade. Unexcused absences or persistent tardiness are grounds for reductions (50% or more) in this component of the grade. To receive full credit for this portion of the grade, students must consistently demonstrate through participation in class discussions that they have completed the required readings and thought through the issues in advance of the class.

Personal carbon audit – 10%. Students will be required to use an instructor-specified internet tool to estimate the greenhouse gas emissions generated by their personal lifestyle. This audit is due by January 25. Details on this assignment, including the format of the report, will be provided during the first week of class. Students may work together on these reports, but each student must submit a personal audit that reflects her/his personal lifestyle.

Technology investment memo – 15%. As a candidate for President, Barack Obama proposed setting up a governmental organization that would invest up to \$15 billion in technologies to mitigate climate change and produce energy in a more environmentally friendly way. You are tasked with writing a 10-page memo that allocates this budget over different technologies and justifies your choices as being the socially optimal ones. You are encouraged to focus your attention on alternative technologies reviewed in class. This memo will be due on March 3. Students are encouraged to work in small groups and submit a joint report.

In-class examination - 20%. There will be an in-class exam on April 7 that will account for **20%** of the total grade. This exam will assess students' mastery of the economic analytical tools and conceptual frameworks developed in Part 3 of the course. The exam will be open-book and open-note, but no collaboration will be permitted.

Final examination – 45%. There will be a final examination, worth **45%** of the total grade, which will be given during the examination period. This exam will be a cumulative exam – all the material of the course is fair game. The exam will be open-book and open-note, but no collaboration will be permitted.

Course Outline:

Class Mtg.	Topic
Jan. 11	Course Overview
<i>Part 1 – What on Earth is Going On?</i>	
Jan. 13	The Science of Global Warming (Guest Lecture: Peter Adams)
Jan. 18	The Economic and Social Impact of Global Warming (1)
Jan. 20	The Distribution of Emissions: Industries, Sectors, Countries, and Regions
Jan. 25	The Economic and Social Impact of Global Warming (2) [Personal Carbon Audit Due]
<i>Part 2 – Technology Alternatives for Mitigation</i>	
Jan. 27	Energy and the Environment (Guest Lecture: Paul O’Neill, Former Secretary of the Treasury and Former CEO, ALCOA)
Feb. 1	Going Nuclear (Guest Lecture: Dr. John Goosen, Director, Science and Technology Department, Westinghouse)
Feb. 3	Carbon Sequestration (Guest Lecture: Ed Rubin)
Feb. 8	Solar and Wind Power (Guest Lecture: Josh Linn, MIT and RFF)
Feb. 10	Biofuels: Can We Grow Our Own? (Guest Lecture: Huimin Tan, Doctoral Candidate, EPP)
Feb. 15	Geoengineering (Guest Lecture: Kate Ricke, Doctoral Candidate, EPP)
Feb. 17	Transportation Options
<i>Part 3 – What Do We Do Now?</i>	
Feb. 22	The Simple Economics of Externalities: Why We Can’t “Just Let the Market Work”
Feb. 24	Does the Price Mechanism Work?: Lessons from the Last “Energy Crisis”
Mar. 1	Estimating the Costs of Climate Change Mitigation
Mar. 3	The Case for a Carbon Tax (1) [Policy Memo on Technology Alternatives Due]
Spring Break March 8-12	
Mar. 15	The Case for a Carbon Tax (2)
Mar. 17	The Case for an Emissions Cap-and-Trade System (1)
Mar. 22	The Case for an Emissions Cap-and-Trade System (2)
Mar. 24	Market Based Mechanisms vs. Command-and-Control Regulation
Mar. 29	Hybrid Policy Mechanisms
Mar. 31	The Business of Carbon Trading (Guest Lecture: Richard DiClaudio)
Apr. 5	International Coordination
Apr. 7	In-Class Exam: Economic Analysis of Climate Change Policy
<i>Part 4 – The Politics of Global Warming</i>	
Apr. 12	The Kyoto Agreement. . . Has It Worked?
Apr. 14	How Do We Bring Developing Countries Into the Fold?
Apr. 19	The Future of Climate Change Policy in the United States (Guest Lecture: William Pizer, U.S. Treasury Dept.)
Apr. 21	The Future of International Policy Coordination on Climate Change

	(Guest Lecture: Dr. Joseph Aldy, Resources for the Future)
Apr. 26	TBA
Apr. 28	Wrap-Up Lecture

Class 1 – Course Overview

January 11

Required Reading

“The Economics of Climate Change,” Lawrence Goulder and William Pizer, *The New Palgrave Dictionary of Economics*, 2nd Edition.

Optional Reading

Economist Survey, “The Heat Is On,” September 7, 2006

Class 2 – The Science of Global Warming

January 13

Required Reading

“The Physical Science Behind Climate Change,” William Collins, Robert Colman, James Haywood, Martin Manning, and Philip Mote, *Scientific American*, August 2007

Optional Reading

Congressional Budget Office (CBO), 2003. “The scientific and historical context,” Chapter 2, in *The Economics of Climate Change: A Primer*.

GUEST LECTURE Professor Peter Adams, Department of Engineering and Public Policy, Department of Civil and Environmental Engineering, CMU

Class 3 – The Economic Impact of Global Warming, Part 1

January 18

Required Reading

IPCC, 2007. *Climate Change 2007: Synthesis Report*, Topic 3 and Topic 5 required.

Recommended Reading

IPCC, 2001. Summary for Policymakers, in *Climate Change 2001: Synthesis Report*. Cambridge: Cambridge University Press, Q3, Q4, Q5, Q6 required.

Optional Reading

Pew Center on Global Climate Change, 2004. D. Jorgenson, R. Goettle, B. Hurd, J. Smith, L. Chestnut, D., Mills. "U.S. Market Consequences of Global Climate Change."

Class 4 – The Distribution of Greenhouse Gas Emissions: Where Do They Come From, How Will They Grow?

January 20

Required Reading

Darmstadter, J, 2003. "The Energy-CO2 Connection: A Review of Trends and Challenges," Chapter 1 in *The RFF Guide to Climate Change Economics and Policy*, Washington, DC: RFF.

Optional Reading

Issue Brief 1 in *Assessing U.S. Climate Change Policy Options*, Washington, DC: Resources for the Future

Class 5 – The Economic Impact of Global Warming, Part 2

January 25

Required Reading

Shogren, J. F. and M. A. Toman, 2003. "How Much Climate Change is Too Much? An Economics Perspective." Chapter 3 in *The RFF Guide to Climate Change Economics and Policy*, Washington, DC. RFF.

Recommended Reading

Newell, R. G., and W. A. Pizer, 2001. "Discounting the Benefits of Climate Change Mitigation: How Much Do Uncertain Rates Increase Valuations?" Report Prepared for the Pew Center on Global Climate Change.

Class 6 – Energy and the Environment

January 27

Required Reading

Issues Online in Science and Technology, National Academies Press, Apt, J., D. Keith, and G. Morgan, "Promoting Low-Carbon Electricity Production."

GUEST LECTURE: Paul O'Neill, Former Secretary of the Treasury and former CEO, ALCOA

Class 7 – Going Nuclear: The Renaissance of the Nuclear Power Industry in an Age of Global Warming

February 1

Required Reading

The *Economist*, September 6, 2007: “Atomic Renaissance”

Optional Reading

D. Whitford, *Fortune*, August 6, 2007, “Going Nuclear.”

GUEST LECTURE: Dr. John Goosen, Director, Science and Technology Department, Westinghouse

Class 8 – Carbon Sequestration February 3

GUEST LECTURE: Professor Ed Rubin, Alumni Professor of Environmental Engineering and Science, Department of Mechanical Engineering, Department of Engineering and Public Policy, CMU

Class 9 – Solar and Wind Power February 8

GUEST LECTURE: Dr. Joshua Linn, Resources for the Future and MIT

Class 10 – Biofuels: Can We Grow Our Own? February 10

Required Reading

E. Rosenthal, “Studies Deem Biofuels a Greenhouse Threat,” *New York Times*, Feb. 8, 2008.

Recommended Reading

Huimin Tan, “Review of Biofuels Policy: Environmental and Economic Implications” [Will be available on Blackboard Website]

M. Grunwald, “The Clean Energy Scam,” *Time*, March 27, 2008.

GUEST LECTURE: Humin Tan, Doctoral Student, Engineering and Public Policy

Class 11 – Geoengineering February 15

Required Reading

S. Schneider, “Earth Systems Engineering and Management,” *Nature*, Vol 409, 18, January 2001.

GUEST LECTURE: Kate Ricke, Doctoral Candidate, Department of Engineering and Public Policy

**Class 12 – Transportation Options
February 17**

Required Reading

D. Sperling and D. Gordon, “Advanced Passenger Transportation Technologies,” *Annual Review of Environment and Resources*, vol. 33, no. 17, 2008.

Optional Reading (only for those who are truly interested)

R. Porter, *Economics at the Wheel: The Costs of Cars and Drivers*, Academic Press, New York, 1999. The entire book is eminently readable and worth it for those interested in the topic.

**Class 13 – The Simple Economics of Externalities: Why We Can’t Just Let the Market Work
February 22**

Recommended Reading

W. Baumol and W. Oates, *The Theory of Environmental Policy: 2nd Edition*, Cambridge University Press, 1988, Chapter 4, “Externalities: Formal Analysis”

**Class 14 – Lessons from the Last Energy Crisis
February 24**

No Required Reading

Students are encouraged to examine posted lecture notes prior to class

**Class 15 – Estimating the Costs of Climate Change Mitigation
March 1**

Required Reading

Ian Parry, “Revenue Recycling and the Costs of Reducing Carbon Emissions,” Chapter 11, in *Climate Change Economics and Policy: An RFF Anthology*, RFF, 2001

Recommended Reading

Lawrence Goulder, “Confronting the Adverse Industry Impacts of CO₂ Abatement Policies: What Does It Cost?” Chapter 12, in *Climate Change Economics and Policy: An RFF Anthology*, RFF, 2001.

Class 16 – The Case for a Carbon Tax (1)
March 3

Required Reading

William Pizer, “Choosing Price or Quantity Controls for Greenhouse Gases,” Chapter 9, *Climate Change Economics and Policy: An RFF Anthology*, RFF, 2001.

Recommended Reading

W. Baumol and W. Oates, *The Theory of Environmental Policy: 2nd Edition*, Cambridge University Press, 1988, Chapter 5, “Uncertainty and the Choice of Policy Instruments: Price or Quantity Controls?”

SPRING BREAK MARCH 8-12

Class 17 – The Case for a Carbon Tax (2)
March 15

Required Reading

Richard Cooper, Chapter 3.1, “The Case for a Global Carbon Tax,” in J. Aldy and R. Stavins, eds, *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*, Cambridge University Press, 2007.

Class 18 – The Case for an Emissions Cap-and-Trade System
March 17

Required Reading

Issue Briefs 5 and 7 in *Assessing U.S. Climate Policy Options*, Washington, DC, Resources for the Future

Class 19 – Selling Air: How Cap-and-Trade Systems Work
March 22

Required Reading

Issue Brief 6, “Allowance Allocation,” in *Assessing U.S. Climate Policy Options*, Washington, DC, *Resources for the Future*

Recommended Reading

S. Labatt and R. White, "Emissions Trading in Theory and Practice," Chapter 6 in *Carbon Finance: The Financial Implications of Climate Change*, John Wiley & Sons, 2007.

Class 20—Market Based Mechanisms vs. Command-and-Control Regulation
March 24

Highly Recommended Reading

W. Pizer et al., 2006, "Modeling Economywide vs. Sectoral Climate Change Policies Using Combined Aggregate-Sectoral Models," *Energy Journal* 27 (3), 135-168.

Class 21 – Hybrid Policy Mechanisms
March 29

Required Reading

W. Pizer, "Practical Climate Change Policy," Chapter 7, in J. Aldy and R. Stavins, *Architectures for Agreement: Addressing Climate Change in the Post-Kyoto World*, Cambridge University Press, 2007/

Class 22 – The Business of Carbon Trading
March 31

Guest Lecture: Richard DiClaudio, CEO of Blue Tip Energy Management

Class 23 – International Coordination
April 5

Required Reading

D. Victor, "Fragmented Carbon Markets and Reluctant Nations: Implications for the Design of Effective Architectures," Chapter 4 in, *Architectures for Agreement: Addressing Climate Change Policy in the Post-Kyoto World*, Cambridge University Press, 2007.

Class 24 – In-Class Examination: Economic Analysis of Climate Change Policy
April 7

Class 25 – The Kyoto Agreement . . . Has It Worked?
April 12

Required Reading

D. Victor, *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*, Chapter 1, "Crisis and Opportunity."

Recommended Reading

D. Victor, *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*, Chapter 2, "Kyoto's Fantasyland: Allocating the Atmosphere."

Optional Reading

J. Anderson, "How the Kyoto Protocol Developed: A Brief History," Chapter 2 in M. Toman, Ed., *Climate Change Economics and Policy: An RFF Anthology*, Washington, DC, RFF.

Class 26 – How Do We Bring Developing Countries Into the Fold?

April 14

Required Reading

M. Toman, "Establishing and Operating the Clean Development Mechanism," Chapter 21, in *Climate Change Economics and Policy: An RFF Anthology*, RFF, Washington.

Strongly Recommended Reading

C. Forelle, "French Firm Cashes In Under U.N. Warming Program," *The Wall Street Journal Online*, July 23, 2008.

J. Ball, "U.N. Warming Program Draws Fire: Fund Designed to Spur Renewable Energy Subsidizes Gas Plants," *The Wall Street Journal Online*, July 11, 2008.

Class 27 – The Future of Climate Change Policy in the United States

April 19

Guest Lecture: Dr. William Pizer, U.S. Treasury Department

Class 28 – The Future of International Policy Coordination on Climate Change

April 21

Guest Lecture: Dr. Joseph Aldy, Resources for the Future

Class 29 – TBA

April 26

Class 30 – Wrap-Up Lecture

April 28